Ultra High-pressure Watercutting – Rejuvenating the microtexture of polished surfacings

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Abstract

There are a number of existing methods for restoring the skid resistance of a pavement surface as an alternative to resurfacing; most of these have focussed on removing excess binder from the surface. Only one of these methods (Ultra High-pressure Watercutting) is capable of restoring both the microtexture and the macrotexture on polished surfaces. The UHP Watercutter combines a truck mounted UHP pump, water supply and vacuum recovery system with an independently operated umbilical deckblaster. A rotating spraybar uses specialised nozzles to direct very fine jets of ultra high-pressure water (36000 psi) at ultrasonic velocity (mach 1.5) on to the road surface.

Preliminary investigations of both laboratory samples and road trial sections have ascertained that ultra high-pressure watercutting can restore the microtexture of polished aggregate to a level close to that of freshly crushed aggregate.

This paper reports on the first year of a Land Transport New Zealand Research Project monitoring the performance of ultra high-pressure watercut existing surfaces, compared with those of adjacent new surfacings, on 10 sites located around New Zealand. This research is primarily investigating the longevity of the microtexture improvement delivered by the watercutter compared with the rate of loss of microtexture of new surfacings laid at the same time as the watercutting treatment was carried out.

Introduction

There are a number of methods for restoring skid resistance of a pavement surfaced besides simply resurfacing. Waterblasting at low to medium pressures (up to 20,000 psi) is an established method of bitumen removal and porous asphalt cleansing. In recent times watercutting technology, employing narrow jets of water under great pressures (in excess of 35,000 psi) has been applied successfully to the process of bitumen removal.

Another associated benefit from this process is the restoration of the microtexture. Preliminary investigations on laboratory specimens Pidwerbesky (2002) have shown that ultra high-pressure watercutting can restore the microtexture of polished aggregate to a level equal to that of freshly crushed aggregate. Road trials show that the skid resistance and texture depth of the restored chip seal surface degrade at a similar rate to that of a new seal. Watercutting can therefore be used as a cost effective resurfacing treatment for macrotexture and microtexture deficient surfaces.

The energy in the fine jets of water travelling at 500m/s is almost entirely dissipated on first contact with the surface, with only the binder, road film, and aggregate surface directly contacted by the jets being removed. The binder underneath the aggregate is not disturbed and the aggregate is not displaced. The high velocity impact causes the binder to act as a solid rather than a viscous fluid so the water jet cuts off particles of binder and aggregate.

Previous investigations Cenek (1998) and Roe (1997) document traditional waterblasting treatments as producing only a short-term improvement on the microtexture of polished surfacings and being only suitable for short-term maintenance on polished sites. Mechanical processes that can deliver longer-term microtexture improvement commonly reduce the macrotexture and life expectancy of the surfacing.

The research discussed in this paper aims to determine whether the ultra high-pressure watercutting surfacing treatment produces a long-term improvement to the microtexture of polished aggregate (while also improving the macrotexture of the surface). This research therefore is primarily investigating the rate of loss of the microtexture improvement delivered by the watercutter compared with the rate of loss of microtexture of new surfacings.

Watercutting Process

The "**U**ltra **H**igh-**P**ressure (UHP) Watercutter" is a machine that combines both watercutting and road cleaning technologies in a single process to simultaneously remove excess binder and contaminants from pavement surfaces, and retexture aggregate surfaces improving road surface macrotexture and microtexture. The UHP Watercutting machine was designed and fabricated in New Zealand.

Large areas of skid deficient road surface have been treated using the UHP Watercutter in the past two years, and all have shown improved microtexture.

The UHP Watercutter equipment comprises the truck mounted UHP pump (See figure 1), water supply, vacuum recovery system and an independently operated umbilical deckblaster (See figure 2) that directs the very high velocity water jets at the road surface. Having an operator on the ground with the deckblaster means that only those areas of the road surface that require treatment can be easily identified and treated. This maximises the useful work achieved, minimises the fuel used and minimises wasted energy. A system mounted entirely on a vehicle cannot deliver this flexibility and efficiency.

The watercutter's cutting head has an effective cut width of 560mm and can restore macrotexture on the road surface. As no heat is used in the process, binder is easily collected within the unit's recovered material tank for recycling.

The UHP watercutter operates at a water pressure of 36,000 psi (2500 bar). This high pressure produces energy intensive jets of water applied to the road surface through a rotating spraybar. The optimum design of the spraybar was determined by theoretical design and subsequent field investigations. The quantity of water used is small (15-20 litres of water per minute); it is the very high velocity of the water (about mach 1.5 or 500m/s) that provides the desired cutting action.

These water jets are energy intensive and very effective at removing the excess binder from the road surface, however their energy dissipates very quickly and they do not have a detrimental effect on the binder that anchors the aggregate in place. No significant aggregate loss has been experienced with this system despite the intense energy involved in the treatment.

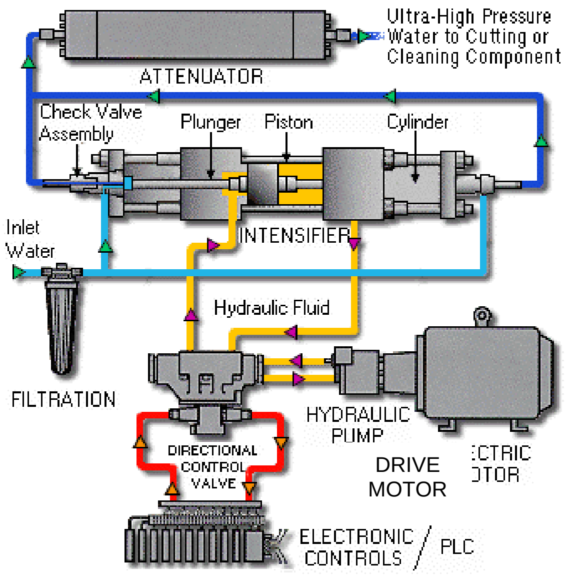

Figure 2. Schematic of the pump operation

The latest design (Figure 2) uses one engine to meet all the demands of water pumping, deckblaster operation and waste vacuum recovery. This design minimises the fuel used and reduces unnecessary weight.

Optimised axle loads enable a full days supply of water and a full days worth of recovered product to be carried. This dramatically improves the efficiency of the whole operation by eliminating the need to travel to and from disposal sites during the day.

Figure 2. Water supply and vacuum recovery system

The recovered product tank on the truck has been designed to cope with the difficult material removed from the road surface. The recovered product contains approximately 20%-30% bitumen based binder and 20%-30% fine aggregate, which settles in the tank. The tank has been designed as a tipping body with a steep tipping angle and a large hydraulically operated rear door. The door seal was carefully designed to provide a watertight seal even with 8,500 litres of water and recovered product on board. The tank is constructed of stainless steel.

Laboratory Investigation

Cenek (1998) suggested that high-pressure waterblasting "…removes the road film which clogs microtexture, but probably does not counter stone polishing." However a subsequent laboratory experiment using the Polished Stone Value test polishing apparatus, British Pendulum portable skid tester, and the ultra high-pressure watercutter confirmed that the UHP Watercutter could restore the microtexture of laboratory polished aggregate specimens to a state similar to the unpolished specimens. The procedure involved:

- Manufacturing PSV (Polished Stone Value) specimens as per BS812
- The surface friction of the unpolished specimens was measured using the PSV configuration of the British Pendulum portable skid tester.
- The test samples were subjected to accelerated laboratory polishing in the Polishing Apparatus.
- The surface friction of the polished specimens was measured using the PSV configuration of the British Pendulum portable skid tester as per BS812.
- The samples were clamped in a specially fabricated holding frame and the watercutter passed over them cutting the surface.
- The surface friction of the watercut polished specimens was measured using the PSV configuration of the British Pendulum portable skid tester as per BS812.

The results of this experiment (See Appendix, Table 1) showed the surface friction could be restored to levels equal to or indeed greater than the initial surface friction. These results provided the impetus to investigate repeating the success shown in the laboratory on actual road surfaces.

Road Trials

Early watercutting work on the state highway network is being monitored, it shows that skid resistance on the watercut sections degrades at rates similar to that of new chipseals in the area.

A trial site located on the motorway north of Christchurch (SH01S – 317/6770-7200 I) has three continuous sections and each has a different treatment history. The entire treatment length (SH01S – 317/6000-9631 I) that includes the trial site was chipsealed with a racked–in grade 3/5 seal using Techniflex PMB105 binder with varied application rates for the variable texture.
The friction and texture data collected from SCRIM and High Speed Data surveys subsequent to the surfacing show a gradual decline over the past 7 years with two lengths Section 1(SH01S – 317/6770-7200 I) and Section 3 (SH01S – 317/7120-7200 I)

Section 1 was watercut in January 2002, Section 2 has not required treatment, and Section 3 was watercut in August 2002. Macrotexture and microtexture data from the SCRIM+ machine from 1998 to present has been summarised in Appendix Tables 2 and 3. Figure 3 shows that the friction levels for the two watercut sections were reset to a level similar to that of the grade 3 and grade 5 two-coat chipseal when it was constructed in 1996 while the friction value for the uncut section has continued to degrade.
This showed that the watercutting process improved both the macrotexture and the microtexture but the rate of deterioration of the restored microtexture was still unknown, and whether the microtexture restoration was applicable to all or only certain types of seals and aggregates remained unproven.

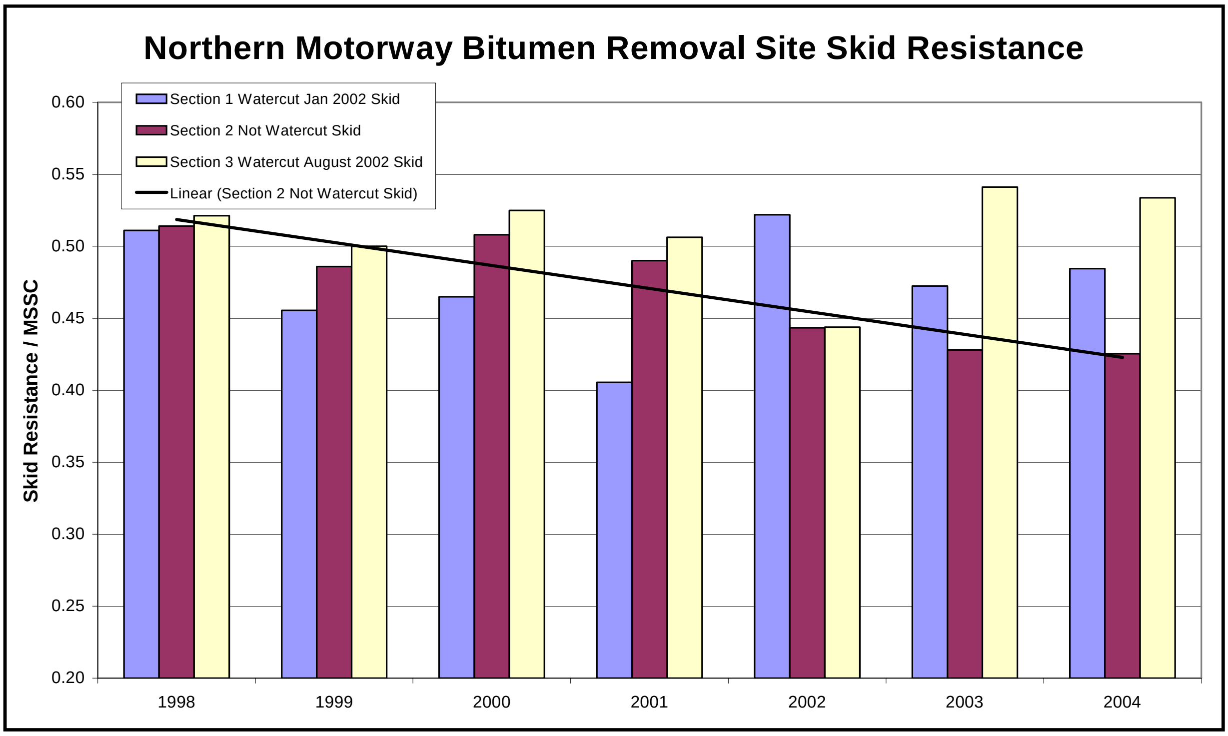

Figure 3. Northern Motorway Trial Site SCRIM+ Skid Resistance Measurements.

Land Transport New Zealand Research Project

In July 2003 Fulton Hogan was successful in getting funding from Transfund New Zealand (now Land Transport New Zealand) for a research proposal to investigate the lifecycle of the restored microtexture of polished road surfacings in comparison with the lifecycle of the microtexture of new chipseals constructed at the same time.

The first objective of the project was to find ten sites located throughout New Zealand that had all failed the SCRIM+ network survey because of polishing of the surface. Ten sites were selected that all provided different traffic, different stresses, different aggregates, and different surfacing treatments that were in the 2003/2004 resurfacing programme.

A 100-300m section of the traditional resurfacing on each of these sites was left out and the surface was treated by watercutting to refresh the microtexture using the ultra high-pressure watercutter. Monitoring is currently being carried out on a 6 monthly basis on all sites using the Griptester, Minitexture Meter, Sand Circles and data from the annual network survey carried out by the SCRIM+. Unfortunately at the time of writing the 12-month testing regime had not been completed and this data is not available. This paper includes data from testing carried out immediately before and after watercutting.

Discussion

All sites showed an improvement to both the microtexture and the macrotexture.

The ten project sites provide a range of surface textures, aggregates, and surfacing types that ensure the research is not just focussing on the most likely scenarios.

Site 1. Tunnel Hill

Compares a watercut (4-5/12/03) 12-year-old grade 3 chips with two adjacent grade 5 chipseals. One using Oamaru Shingle Quarry Grade 5 sealing chip (sealed 19/11/03) and the other using Balclutha Quarry Grade 5 sealing chip (18/11/03).

Site 2. Tumai Overbridge

Compares a watercut (2-3/12/03) 5-year-old grade 3/5 chipseal using sealing chip from the Oamaru Shingle Crushing Plant with a new grade 3/5 chipseal using Oamaru Shingle Crushing Plant sealing chip (sealed 20/11/03).

Sites 3 & 4. Whangamoa Hill & Saddle

Compares watercut 5-year-old grade 3 and grade 3/5 chipseals constructed with Appleby Quarry grade 3 and grade 3/5 sealing chips with Grade 3 and Grade 3/5 chipseals constructed 13-14/1/04 using sealing chips sourced from the Bartlett's Road Quarry which has a similar source to the Appleby Quarry.

Site 5. MacKays Crossing

Compares the polishing of a watercut (28/1/04) 15-year-old grade 3 chipseal constructed using sealing chip sourced from the Otaki River Crushing Plant with the previous rate of polishing. The chipseal surface was very worn, rounded, and polished.

Sites 6, 7 & 8 Napier SH5

Compares the polishing of watercut (3-4/3/04) polished 4-5 year old chipseals constructed using Whitehall Quarry grade 2 and grade 2/4 sealing chips with grade 2/4 chipseals constructed (24-25/2/04) using sealing chip sourced from Poplar Lane Quarry.

Site 9. Rosebank Off Ramp

Compares the polishing of a watercut (12-13/1/04) polished porous asphalt with a Stone Mastic Asphalt surface paved (12-13/1/04) using SMA 11mm manufactured using a blend of Motouhora Quarry and Reliable Road Quarry aggregate.

Site 10. Te Atatu Off Ramp

Compares the polishing of a watercut (12-13/01/04) AC 10mm with a Stone Mastic Asphalt surface paved (12-13/1/04) using SMA 11mm manufactured using a blend of Motouhora Quarry and Reliable Road Quarry aggregate.

All watercut sites showed a substantial improvement in skid resistance. The average improvement for all of the sites was 0.17 Gripnumbers in the wheelpaths, and the average improvement per site ranged from 0.10 to 0.33 Gripnumbers. The average improvement between the wheel paths was 0.14 Gripnumbers, and the average improvement per site ranged from 0.08 to 0.34 Gripnumbers. Examples of the data showing the site skid resistance improvement are included in the following text.

During the research it was observed that as anticipated the watercutter did not restore the sharp edges to the surfacing aggregate and therefore the freshly watercut surfaces may create less hysteretic friction than new chipseals because they lack the sharp edges and irregular surfaces provided by freshly crushed aggregate and relatively untrafficked chipseals.

Tunnel Hill Site Friction Change

Figure 4 shows the Griptester Measurements for the Left Lane Left Wheelpath over the entire Tunnel Hill Site including: the 11-year-old Roxburgh Grade 3 chipseal section (the control), the 14–day-old Oamaru Shingle Grade 5 chipseal section, the watercut 12-year-old Roxburgh Grade 3 chipseal section, and the 15-day-old Balclutha Grade 5 chipseal section. On this site the chipsealing had been completed before any Griptesting took place so only watercutting took place between the before and after Griptesting.

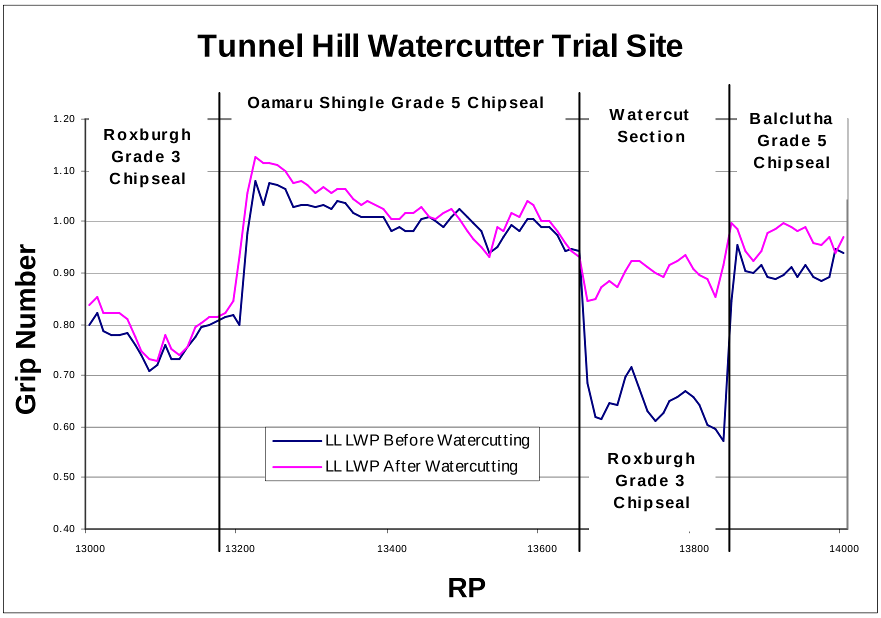

Figure 4. Tunnel Hill Watercutter Trial Site

Rosebank Off Ramp Site Friction Change

Figure 5 shows the Griptester Measurements before and after resurfacing for the Left Wheelpath for the entire length of Rosebank Site. The data includes: the untouched OGPA that was the control section, the watercut section, and the section resurfaced with SMA. On this site the griptesting was carried out over the entire site before any resurfacing was carried out, the watercutting and laying of SMA took place then the griptesting was carried out over the entire site. The change in skid resistance on the control section is due to environmental factors as the section was untrafficked and so physically unaltered during watercutting and the laying of the SMA.

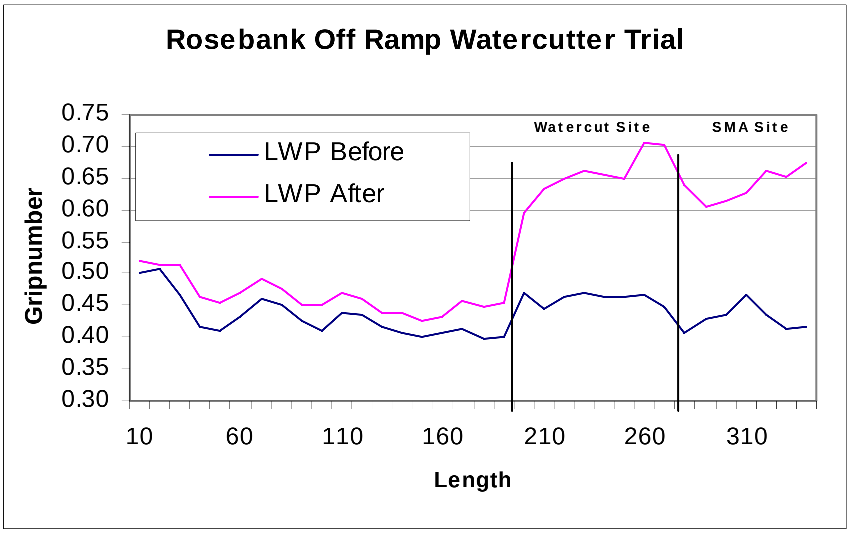

Figure 5. Rosebank Off Ramp Watercutter Trial Site

Site Texture Change
The macrotexture on the sites showed a small increase in the wheelpaths, the average SMTD increase for all of the sites was 0.14mm with a range from 0mm to 0.45mm. The average SMTD improvement between the wheelpaths was 0.15mm. Relatively small changes to the texture depth were expected as only polished sites without flushing were chosen for the study. No sites had any indication of flushing or binder rise during the initial inspections, however some isolated areas of flushing and binder rise were encountered on sites 2,3,4,6,7&8, and the rejuvenation process removed the excess binder from these areas. This means that the change in texture depths measured were the result of removal of the isolated flushed areas, detritus and other road grime from the surfacing interstices.
Examples of the texture change over two of the sites are provided in the following text.

Wishing Well Site Texture Change
Figure 6 shows the Minitexture Meter measurements for the Right Lane Left Wheelpath on the Wishing Well Site Watercut Section. The change in texture depth is relatively small because the existing seal was polished with only minor areas with binder rise.

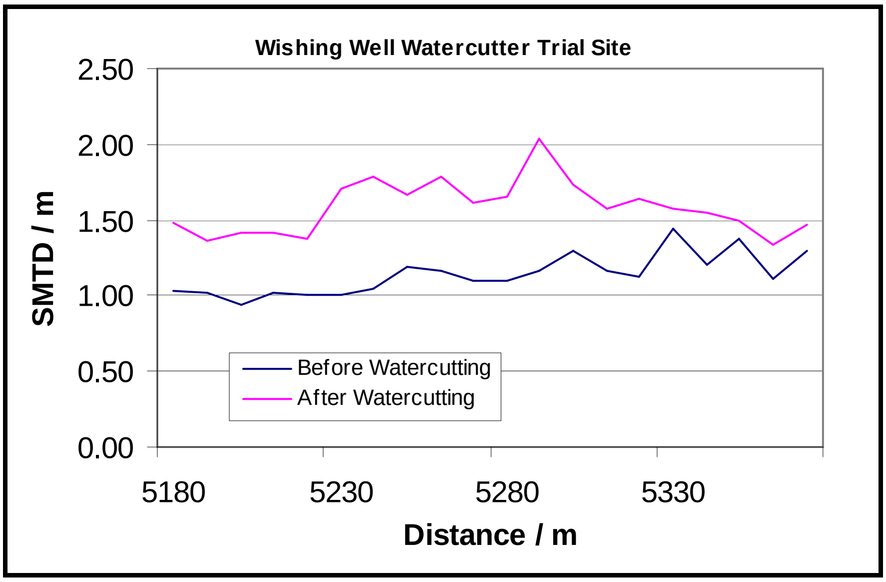

Figure 6. Wishing Well Texture Measurements.

Rosebank Off Ramp Site Texture Change
The change in texture depth on the polished porous asphalt surface was due to the watercutter removing the detritus from the surface voids while refreshing the microtexture on the aggregate. Figure 7 shows the substantial improvement (0.5mm SMTD) on the texture depth.

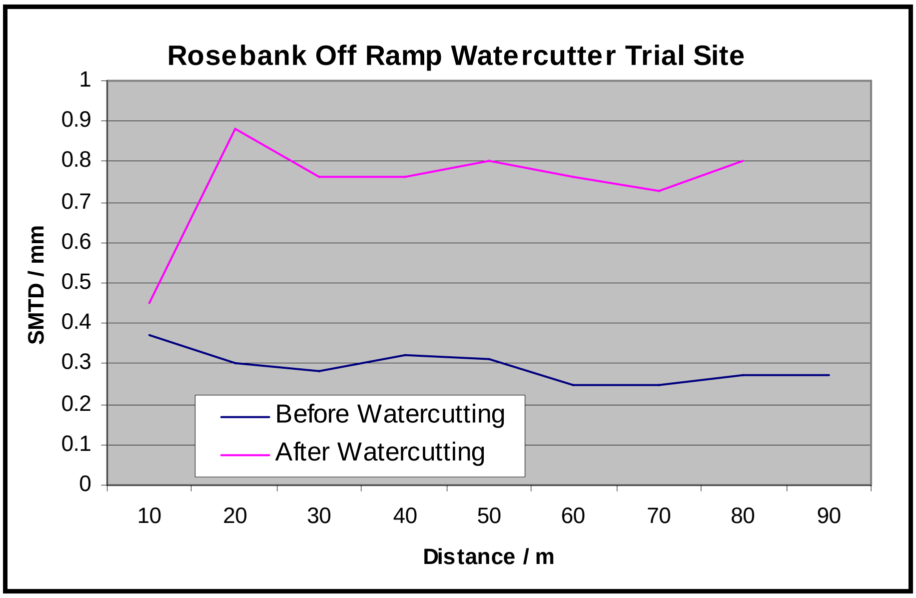

Figure 7. Rosebank Off Ramp Texture Measurements.

Conclusions

1. The initial testing of the polished sites before and after the watercutting process confirmed that watercutting a polished surface results in an increase in both macrotexture and microtexture of the surface.
2. The watercutting process is capable of increasing the skid resistance from levels below the specific site requirement to levels above the specific site requirements.
3. The initial measurements of surface texture of the polished sites before and after watercutting showed that in general there was an increase in texture depth. However as the sites were supposed to be polished and not flushed it was not expected that there would be a significant improvement.
4. There is a significant difference between the skid resistance in the wheelpaths and the less trafficked path in between.

References

Cenek P.D., Jamieson N.J., Locke N.J. & Stewart P.F., (1998). Selection of cost effective skid resistance restoration treatments.
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Pidwerbesky, P.D. (2002). FH UHP Watercutter. *Internal Report Distributed Fulton Hogan Roadshow 2002.*

Roe P.G., Hartshone S.A., (1997). Mechanical retexturing of roads: a study of processes and early-life performance.
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Appendix – Data Tables

Type of Stone [and Source]	Skid Resistance Prior to Accelerated Polishing (Lab PSV Units)	PSV (After Accelerated Polishing as per BS812)	Skid Resistance After UHP Watercutting (Lab PSV Units)
Control	61	52	66
Greywacke (Uriti)	Not Tested	55	85
Blue Rock (Hard Rock) [Plimmerton]	Not Tested	55	67
Brown Rock (Overburden) [Plimmerton]	Not Tested	64	81
Greywacke (Pound Rd) 20% rounded faces	72	57	70
	72	58	71
Control	62	53	68

Table 1. Laboratory Experiment Results

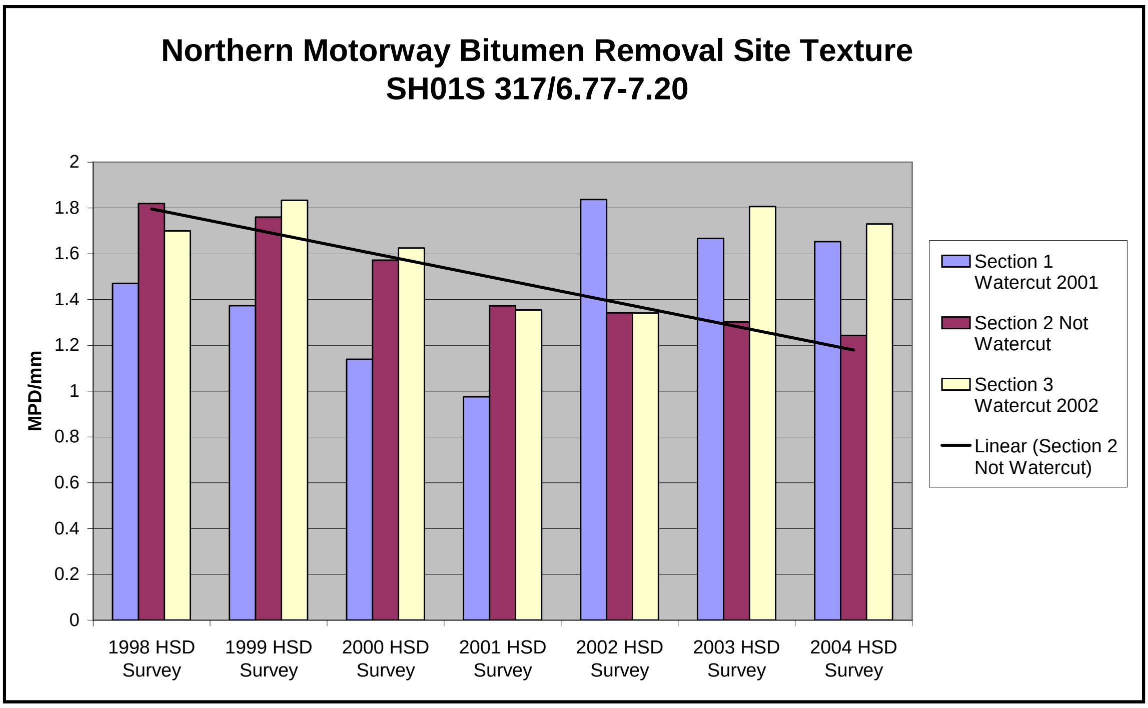
	1998 SCRIM Survey	1999 SCRIM Survey	2000 SCRIM Survey	2001 SCRIM Survey	2002 SCRIM Survey	2003 SCRIM Survey	2004 SCRIM Survey
Section 1	0.51	0.46	0.47	0.41	0.52	0.47	0.48
Section 2	0.51	0.49	0.51	0.49	0.44	0.43	0.43
Section 3	0.52	0.50	0.53	0.51	0.44	0.54	0.53

Table 2. Northern Motorway Test Section Average Surface Friction (MSSC) from SCRIM survey.

	1997 HSD Survey	1998 HSD Survey	1999 HSD Survey	2000 HSD Survey	2001 HSD Survey	2002 HSD Survey	2003 HSD Survey	2004 HSD Survey
Section 1	1.77	1.47	1.37	1.14	0.98	1.84	1.67	1.65
Section 2	2.05	1.82	1.76	1.57	1.37	1.34	1.30	1.24
Section 3	2.28	1.70	1.83	1.63	1.35	1.34	1.81	1.73

Table 3. Northern Motorway Test Section Average Surface Texture (MPD/mm) from HSD survey.

Appendix 2



Graph 1. Northern Motorway Watercutter Trial Site Texture